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Multi-scale finite element modelling of cross-laminated timber plates and experimental validation

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In recent years, cross-laminated timber (CLT) has become a new generation of lightweight and prefabricated systems, whose use has been increasingly spreading over Europe and elsewhere, particularly in the construction sector. CLT panels consist of several layers of boards stacked crosswise and glued together on their faces. Different methods have been adopted for the determination of the basic mechanical properties of CLT, comprising analytical and experimental approaches. However, to date no method has been universally accepted by CLT manufacturers and designers.

The aim of this work is to investigate the mechanical behaviour of CLT plates by a multi-scale finite element approach. A computational homogenisation procedure is adopted within a multi-scale modelling framework to determine the constitutive response of timber. An important aspect to consider in this work is the uncertainty existing in the material description at different scale lengths. In order to take this into account, we perturb several micromechanical parameters of the material. To validate the present multi-scale framework, we carry out several experimental tests on CLT plates subject to bending, shear and compressive loads. In particular, we compute the force-displacement curves for the tested plates and their Young's modulus and shear modulus parallel and perpendicular to the major strength direction. Our numerical predictions are validated successfully, revealing the potential predictive capabilities of the present multi-scale modelling for the analysis of wood materials and timber structures.

Keywords: multi-scale modelling, CLT, timber, finite elements